

University doctoral (PhD) dissertation abstract

ECONOMIC EFFICIENCY ASSESSMENT OF HUNGARIAN DAIRY FARMS

Krisztián Kovács

Supervisor:
Dr. István Szűcs
associate professor



UNIVERSITY OF DEBRECEN
KÁROLY IHRIG DOCTORAL SCHOOL OF MANAGEMENT
AND BUSINESS ADMINISTRATION

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1 RESEARCH BACKGROUND, OBJECTIVES AND HYPOTHESES

Milk and milk products play an important role in human nutrition, thus milk production is an important issue in the global food supply chain, particularly in developing countries. Milk is one of the most valuable human staple foods of high nutrition value. Although many nutrients and vitamins are found in vegetables and can be produced synthetically as well, this type of animal protein is essential for a balanced diet.

Based on these, in terms of the global nutrition supply it is essential to increase milk production efficiency in the future to meet the enormous dairy product demand of explosive population growth. In an economics and social point of view, increasing the efficiency level of the milk production is a highly important area of the European Union (EU) and Hungarian agriculture as well. In general, the efficiency is a very broad concept, it is necessary to define accurately what we mean by it, what factors influence it, what are the assessment indicators and what methods can be used to measure the efficiency of a single dairy farm. The question of efficiency should be a priority area for both the European Union and Hungarian dairy farms to ensure that a single dairy farm can also produce competitively and efficiently for the national and global markets in an economically, socially and ecologically sustainable way.

Oligopolistic Hungarian dairy processors show a price setting behaviour against the milk producers, who have to follow a price-taking behaviour in the market because of their low level of market concentration. If milk producers would like to increase their profitability, resulting almost exclusively from the preceding, the only way they can follow is to increase their efficiency level.

1.1 Objective and research questions

The **general objective** of my research was to explore the main indicators of the dairy sector in the world, the European Union and Hungary, and then define and systematize their efficiency and the factors relevant concerning dairy farms. Moreover, my objective is to introduce the most commonly used methods for measuring efficiency, which can explore hidden reserves within the sector. During my research, I seek to find the answers to the following general objective related questions, and I will give the answers in the chapters of my thesis. I put forward **specific objectives** regarding the general objectives, they are the following:

- 1) What are the **most important** indicators of milk production at the sectoral level, and **how were** these metrics **changed in the** world, the European Union and Hungary?
- 2) Regarding milk production efficiency, which are the most dominant factors at production levels?
- 3) What differences are observed in the technical efficiency indicators in the case of small producers and large-scale farms at the national level?
- 4) What differences have been identified between the partial efficiency and the technical efficiency indicators of milk production?

1.2 Research hypotheses

During the research, in line with my general and specific objectives, the following **hypotheses** were set up:

- H1. For reasons of economies of scale, large size Hungarian dairy farms could produce in a more efficient way than small farms from a technical point of view in 2001- 2013.*
- H2. The technical- and major partial efficiency indicators of individual- and corporate farms are not significantly different.*
- H3. In terms of feed utilization efficiency, large size dairy farms were more efficient than small farms.*
- H4. The results of the most commonly used methods to analyse the technical efficiency (DEA and SFA) are approximately the same.*

H5. The main partial efficiency indicators show similar differences in different years, economics sizes and legal forms, as commonly used methods to analyse the technical efficiency (DEA and SFA).

To achieve my research objective, first the main indicators of the industry will be introduced, which will be explained in the first part of the literature section. The chapter where I introduce the dairy sector will be divided into separate sections where I describe the world, the European Union (28) and the Hungarian production, consumption and trade trends and indicators where mainly FAOSTAT, EUROSTAT, CSO (Hungarian Central Statistical Office) and AKI (Research Institute of Agricultural Economics) databases were used as sources.

In the literature review section, I used 143 Hungarian and international sources, where the methodologically outstanding papers were FARRELL (1957), BARTTESE - COELLI (1992) and COELLI et al., (2005). These studies represent the general basis of technical efficiency research methodology in the international literature from a methodological point of view.

There are two main well known research practises for testing efficiency in international scientific literature, thus I will explain and then use these two ones in my thesis through my efficiency analyses.

For my assessment, I will use the most reliable and comprehensive domestic agricultural economics database, the AKI- FADN¹ database. In accordance with my objective, based on the database, a representative sample was selected in my analyses to represent the national dairy sector.

¹ FADN is the abbreviation of the „Farm Accountancy Data Network”; which is a European Network for gather accountancy data from farms for the determination of incomes and business analysis of agricultural holdings. Currently, the annual sample covers approximately 106 000 Hungarian producer holdings.

2 MATERIALS AND METHODS

The secondary database provided by the AKI (Research Institute of Agricultural Economics) included financial data from 1 435 holdings in the reviewed period. After the elimination of outlier data records (mainly negative values), 934 dairy holdings were left in my database. The data are collected each year and are usually expressed in EUR. Here we had the first barrier which comes in various time series data, as they are not directly comparable due to the time value of money and inflation. For these reasons, a single time base was necessary to choose – in my case the base was the year 2000 –and the input data were deflated.

2.1 The method of data collection and processing regarding the deterministic and stochastic model

After the input data deflation, I created a stochastic (SFA) and deterministic (DEA) model adapted to Hungarian dairy farms in which the output variables were the cow's **milk and milk products** variable and as another income, the sold **beef and veal** variable. In the model, I used five input variables, namely: (1) **total fixed assets**, (2) **total current assets**, (3) **labour input**, (4) **major cost items**, (5) **dairy cows**. Both input and output factors of the model were derived from the Hungarian FADN database. The 104 608 data points were analysed in the model, which includes data from about **934 dairy farms in Hungary**.

After the systematization of the collected data from the FADN database as possible model variables, I performed the data deflation and cleared the outlier values, then finally merged the data from 2001 to 2013. After all, of this, I could start to filter the database in accordance with my categorization criteria, such as the creation of sub-databases with my categories. Such categorization criteria were:

1. Various **years** from 2001 to 2013;
2. farm **size** (small, medium and large);
3. **legal form** (individual- and corporate holding).

In addition to these categorical terms, I ran two parameterised research methods (**DEA and SFA**). I assumed **output orientation** in the case of DEA and SFA models, which implies that the farms in the research, where we estimate how much output quantities can be proportionally expanded (maximised) without altering the input quantities used. For the end result, it has no effect assuming input or output orientation, the two results have to be the same. The results obtained by this can use the milk production farms in the database. To make a valid nationwide conclusion, the data should be weighted by the farms' relative national weight. Its performance inside the technical efficiency measurement models (DEA and SFA) will make the model too complicated and cause unreliable results. This can be avoided if the model itself is not applied to the weights, but individual efficiency values provided by the model are weighted at the end of the procedure. In the weighting procedure, weighted statistical averages were calculated for each categorization criteria for each category. This is more time-consuming, but I think it gives more reliable results than the model built by the weighted method. At the frontier estimation, it does not matter that a point in the model represents 5 or 50 holdings (or decision making units (DMU)). In my method, the categorization criteria weights play an important role at the post-weighting efficiency results. The relative economic weights used in the model came from AKI adopted by the EU.

During my examination set by the research hypothesis, efficiency indicators of dairy farms were analysed from the year 2001 to 2013. As I set in my tasks, I also explore the efficiency level of small, medium and large holdings. The last examination focused on the technical efficiency of individual and corporate enterprises. Naturally, efficiency values should also be weighted at the end to draw national-level conclusions. To do so, a weighted statistical average was calculated using the AKI's FADN system adopted weights calculated for each category. The weighting missed on the year's category, because here the results will not affect the weights.

A number of partial efficiencies can be formed to compare economic and technological aspects of dairy farm efficiency. In the partial efficiency part of my research, there are four areas to assess efficiency

ratios, which were **capital efficiency, labour efficiency, cost-efficiency and herd efficiency.**

To identify the partial efficiency indicators I used the following **variables** from the FADN database: **(1) Cows' milk & milk products** (*values expressed in EUR in the database under the following code: SE216*); **(2) Beef and veal production**, means the sold beef and veal (*values expressed in EUR in the database under the following code: SE220*); **(3) Production values:** means the amount of milk- and milk products and the beef- and veal production, which will be added the industry related subsidies as well (*values expressed in EUR in the database and can be calculated using the following codes: SE216 + SE220 + SE616 + SE617*); **(4) Subsidies dairying:** the value of the dairy premium and aids (*values expressed in EUR in the database under the following code: SE616*); **(5) Subsidies other cattle:** all farm subsidies received for cattle other than dairy cows in production (*values expressed in EUR in the database under the following code: SE617*); **(6) Milk yield** average production of milk and milk products (in milk equivalents) per dairy cow (*values expressed in kg/dairy cow/year in the database under the following code: SE215*); **(7) Annual milk production:** the amount of milk and dairy products produced by a dairy farm in a year (*values expressed in kg/holding/year in the database and can be calculated using the following codes: SE215 + SE085*); **(8) Total fixed assets:** agricultural related land and buildings included, expressed in EUR, which is at the same facility permanently, or at least a prolonged period of economic activity, while production stock of only slightly or even not used up. *In the FADN database under the following code: SE441.* **(9) Dairy cows:** This category of European livestock units (LSU) contains female bovine animals on the farm, which are primarily kept for milk production. The European livestock unit of dairy cows is 1, and the calves younger than two years of between 0.4 and 0.6 take into account. *In the FADN database under the following code: SE085.* **(10) Feed for grazing livestock:** concentrated feed (including various salt licks and preservatives), fodder and fodder mass values expressed in EUR. *In the FADN database under the following code: SE310;* **(11) Labour input:** Time worked in hours by total labour input on holding. *In the FADN database under the following code: SE011;*

(12) Total labour input: total labour input of holding expressed in annual work units = full-time person equivalents. *In the FADN database under the following code: SE010;* **(13) Wages paid:** wages and social security charges (and insurance) of wage earners. Amounts received by workers considered as unpaid workers are excluded (*values expressed in EUR in the database under the following code: SE370*); **(14) Total specific costs:** includes all direct costs related to milk production, which are incurred in the sector in the current year. *Their values expressed in EUR in the database under the following code: SE281*); **(15) Net income:** the difference between the calculated production value and direct production costs. From farm business point of view, it gives the total amount of coverages of a sector. *Their values expressed in EUR in the database and can be calculated using the following codes: (SE216+SE220+SE616+SE617)-SE281.*

Straight and reverse indicators were also made for the partial efficiency indicators. First of all, results are available by using inputs and the single-unit expenses necessary to achieve the result indicators focused on milk production. Also, expenditures/expenditures and income/income related indicators were created.

3 MAJOR FINDINGS OF THE THESIS

During my research, I introduced the current situation of milk production and their main indicators in the world, the European Union and Hungary, and then models were created using parametric (SFA) and nonparametric (DEA) methods of efficiency, after that I developed a system of partial efficiencies and presented practical application of the different efficiency methods for dairy farms.

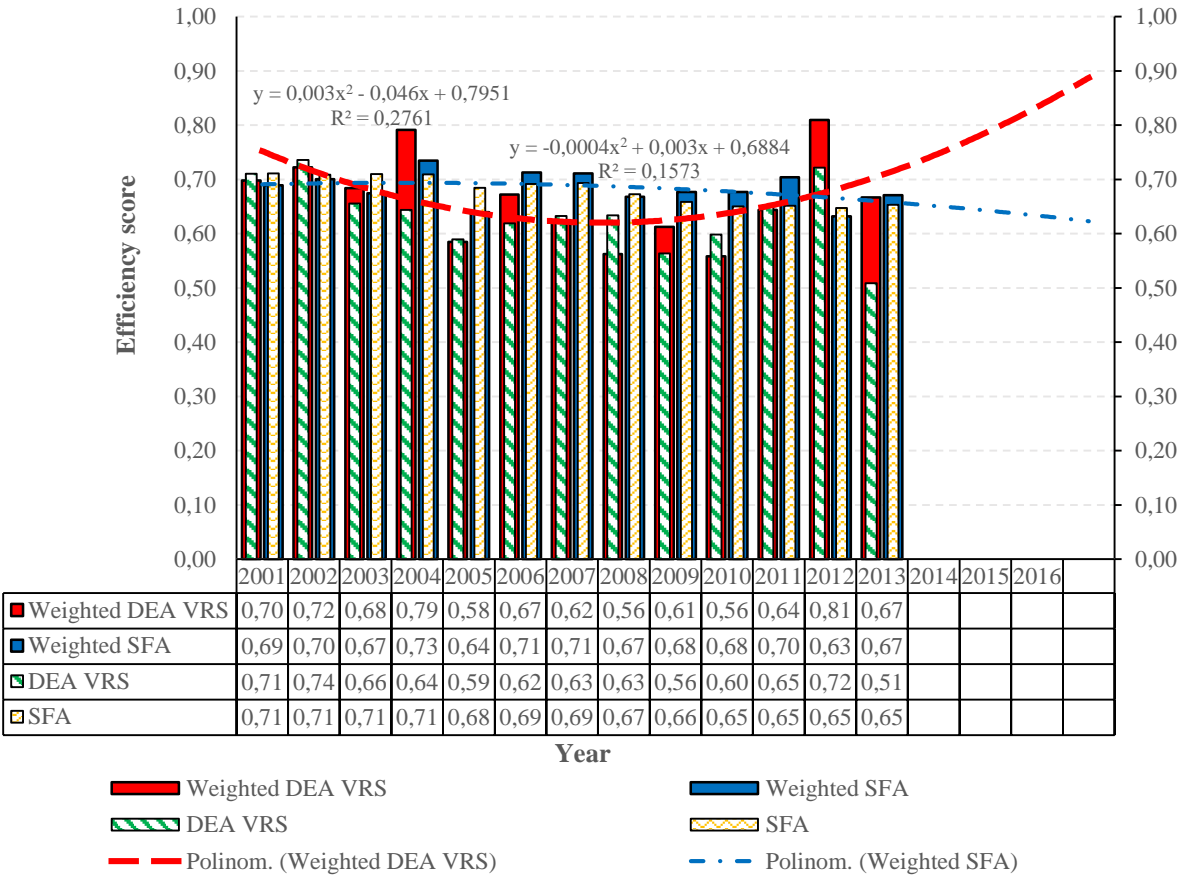


Figure 3.1: Differences between the DEA and the SFA technical efficiency, and there weighted values in different years

Source: Own calculation based on the AKI FADN database

The analysis of the *Figure 3.1* also shows that in some years, such as in the years 2004 and 2012 the value of the outstanding efficiency score was compared with other years, and in the years 2005 and 2010 it fell below the average efficiency. Figure 3.1 compares the results obtained by the two efficiency methods. If we consider the average efficiency values and frontier for the 13 years, the minimum difference between

the two methods is only 2-4%, depending on whether weighting was used or not. In some years, there are already differences in the efficiency results of the two methods. The biggest difference in the year 2010 and 2008, where 8-13% of the differences can be observed. Although it must be added, these are very extreme cases.

In summary, on the basis of the two methods (DEA and SFA), we can say that the efficiency score of the Hungarian milk production ranged from 66-68% from 2001 to 2013. This means that the sector has a 32-34% effective reserve (inefficiency), which it could potentially achieve if it used its resources on an optimal level.

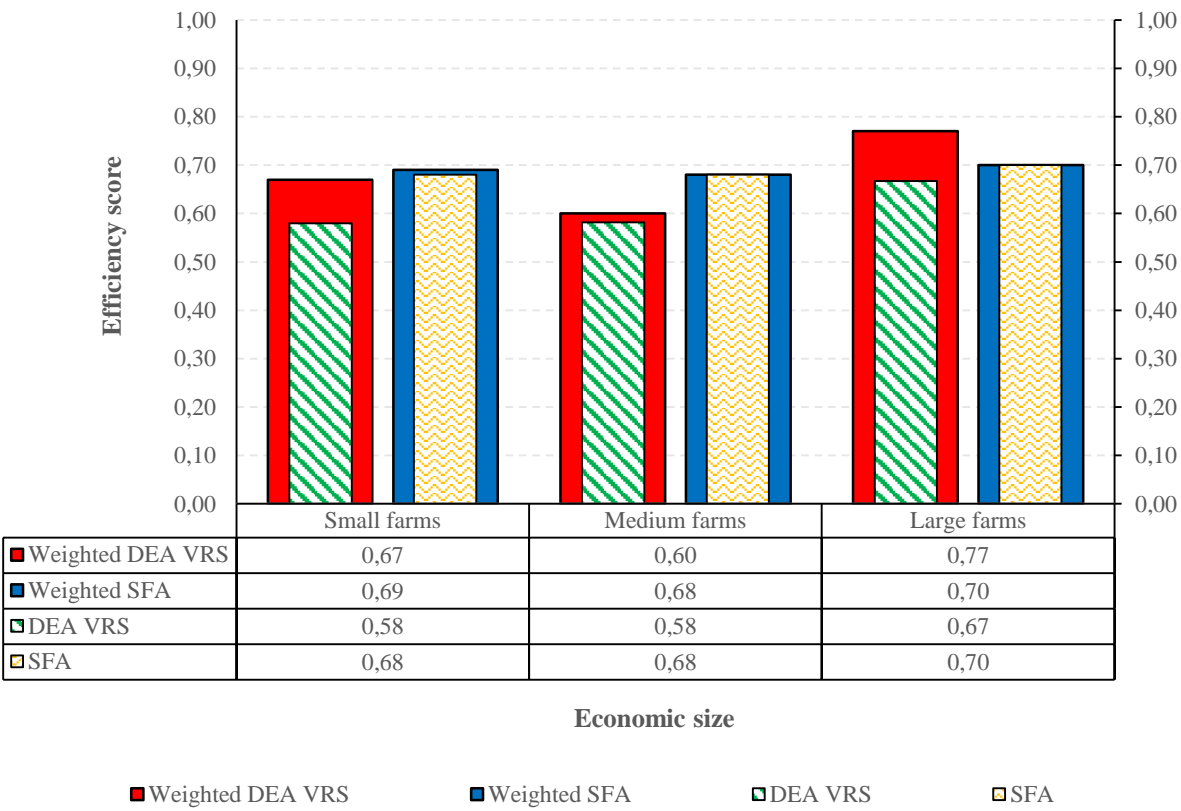


Figure 3.2: The technical efficiency and its weighted values based on two methods of technical efficiency with different farm sizes

Source: Own calculation based on the AKI FADN database

The following research questions covered the examination of the economics of scale. *Figure 3.2* presents the result of it. If a single theoretical efficiency frontier curve is created from the sample farms and the results are grouped according to their size, the average weighted

efficiency score varies about 70-71%. This means that 29-30% effective reserve (inefficiency) is formed.

As Figure 3.2 also presents the weighted DEA VRS and weighted SFA method, it can be clearly stated that large farms are more efficient (70-77%) than small (67-69%) and medium (60-68%) size dairy farms. For the 13 years, it can be seen that on national level the efficiency scores of the medium size farms (60-68%) are the smallest.

My research on individual and corporate enterprises also dealt with questions of efficiency, *Figure 3.3* presents the results and an auxiliary table below quantifies it. Both methods of technical efficiency mean weighted DEA VRS and the weighted SFA (and also the unweighted) results show that the corporate farms efficiency scores (72-74%) are greater than the individual holdings (68%). Based on these we can state that in the examined years, the corporate dairy farms technical efficiency was higher than that of the individual holdings.

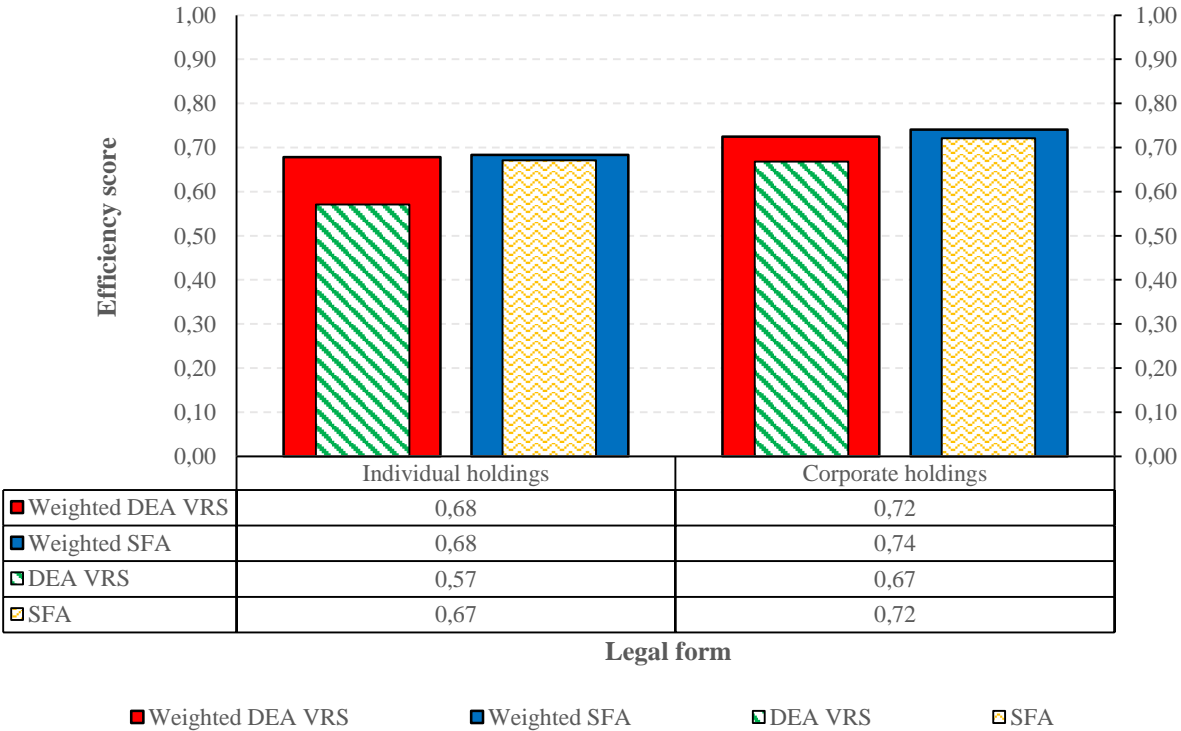


Figure 3.3: Technical efficiency and its weighted values based on two methods of technical efficiency in different legal forms

Source: Own calculation based on the AKI FADN database

In conclusion, we can say that in the case of deterministic and stochastic models the prior assumption was that a single common technical efficiency frontier was estimated, which can be defined from the data of all farms in the sample. The efficiency score of individual farms are compared to the common theoretical efficiency frontier and then they are categorized by terms of years, farm size and legal form to get to the single efficiency score values to be paired with their economics farm weights.

An other assumption of the model, output orientation, means that we want to minimize production inputs in the mean time without changing the output quantities. The number of large and small farms are quite similar (146 and 201 farms) in the sample while the number of medium sized farms are significantly higher (578 farms). These rates correspond to the actual national farm size share.

In the examined years, we can say that the model variables of the efficiency of the Hungarian milk-producing farms (individual and corporate) had an average of **66%** based on DEA method. This means that the average inefficiency score of Hungarian dairy holdings is 34% and it means that they use their available inputs moderately well to their potential ability; whereas those available production levels (milk and beef) were on average 34% increase would be possible.

If we assume a common frontier of the SFA model, the average efficiency score is **69%** on a national level, of which weighted value is also **69%**. This means that if all dairy farms are in the common theoretical frontier creation, we can reserve an average of 31% efficiency in the domestic milk production.

Both models present significant efficiency reserves in Hungarian dairy farm sites. These reserves occur in different areas, depending on which year to talk about, how the farm size and legal form occur. Although the latter two often show a very strong correlation with each other.

In the section of partial efficiency, I **examined 29 indicators**, which are divided into four categories: **capital efficiency, labour efficiency, cost-efficiency and herd efficiency**. I analysed the results of the partial

efficiency indicators in each year separately, and for each the size categories and legal types of farming for thirteen years.

Among the capital efficiency indicators I would like to emphasize the **invested fix asset values per 100 kg of milk yield**, according to that the average of the last thirteen years small farms 114.22 EUR invested fix asset per 100 kg of milk yield, which in the case of large farms 31.57 EUR/100 kg (Figure 3.4). This ratio is valid for the case of individual and corporate holdings too, which suggests that in the domestic milk production generally individual farms are small farms, while large farms tend to operate as a corporate holding.

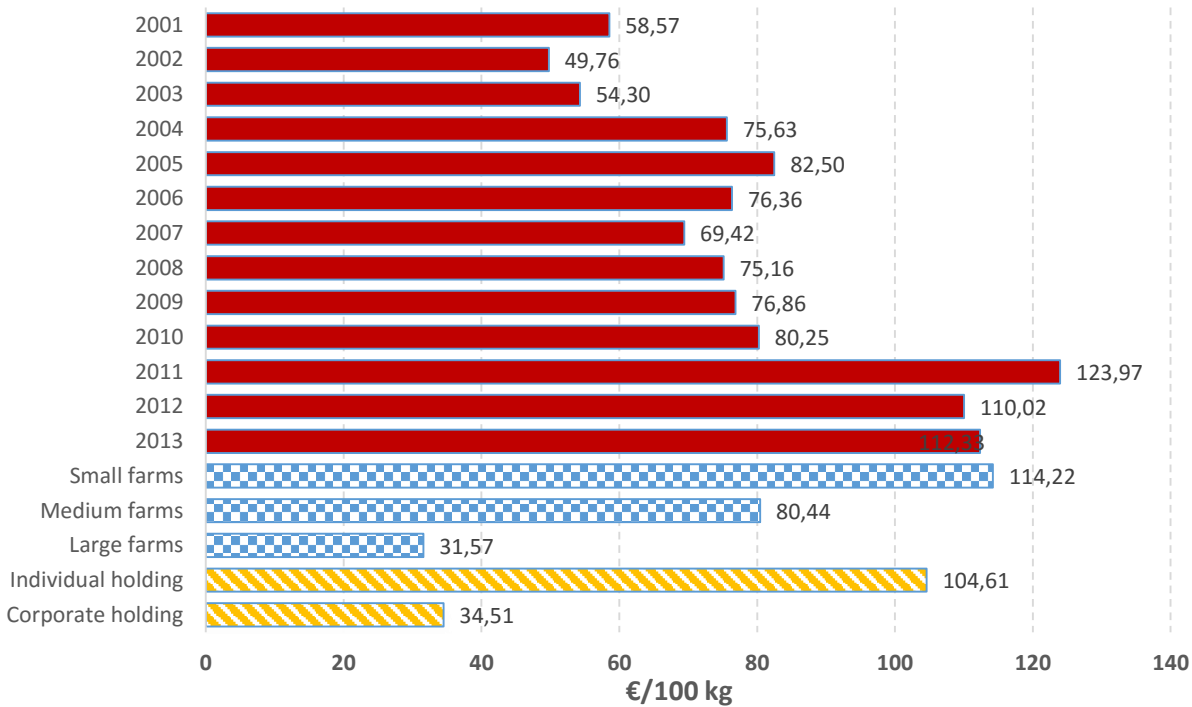


Figure 3.4: Invested fix asset value per 100 kg of milk yield

Source: Own calculation based on the AKI FADN database

The indicator of **hours to produce 100 kilograms of milk** presents (Figure 3.5) the superiority of large farms (3 hours/100 kg) compared to the small farms partial efficiency score (12,1 hours/100 kg).

Among the cost efficiency indicators, the **100 EUR feeding cost per annual milk yield indicator** can be the most important in the dairy sector. With 100 EUR of feeding cost, the large farms are able to produce 999.3 kg of milk, while the small farms only 879.2 kg of milk.

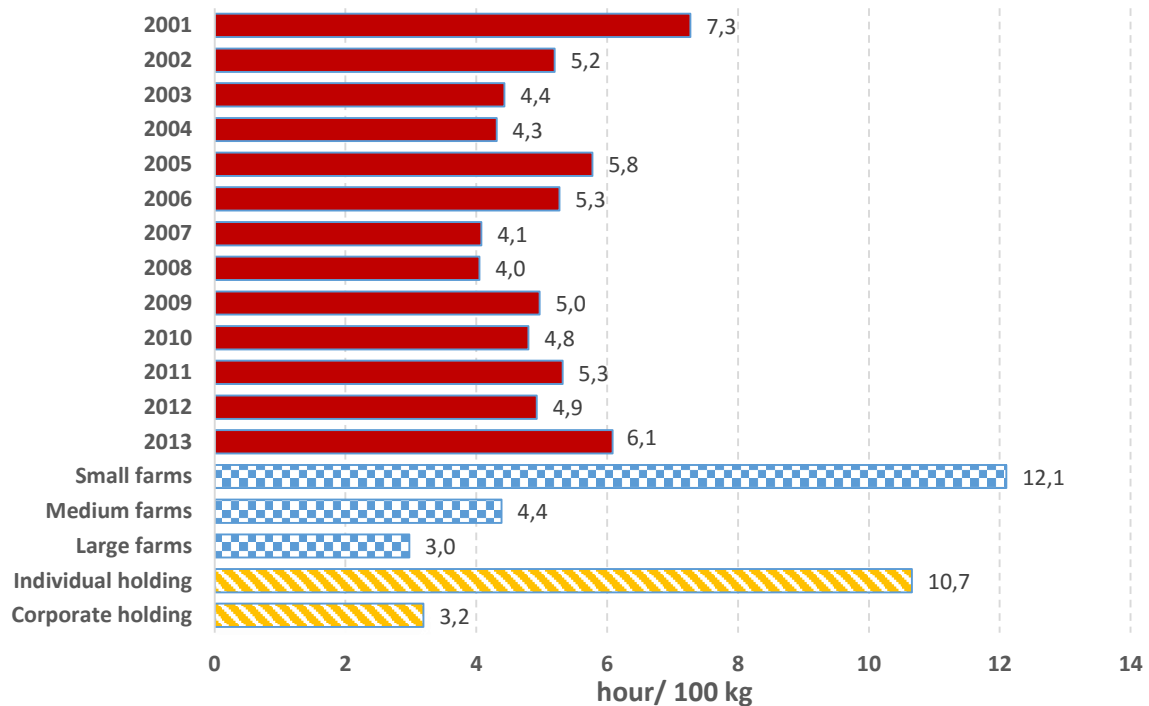


Figure 3.5: Hours to produce 100 kilograms of milk

Source: Own calculation based on the AKI FADN database

Among herd indicators, the **production value per dairy cow indicators** represents the best the differences among the different farm sizes and legal forms. This indicator also draws attention to the fact that that large farms produce the highest production value per dairy cow (1 857 EUR/dairy cow) against small farms where the value of this indicator is 1 337 EUR/dairy cow.

The 29 partial efficiency indicators also proved large farms' great advantage in efficiency scores against the small dairy farms. It can be concluded that the efficiency of the milk-producing small farms is below the level of efficiency of large farms. At the national level corporate dairy farms have higher efficiency scores than the individual dairy farms by 6 percent.

During my research, I was looking for the answers of the following research hypotheses in line with the general objectives:

H1. For reasons of economies of scale, the large size Hungarian dairy farms could produce more efficient way that small farms in a technical point of view in between 2001 and 2013.

This assumption has been confirmed with a multi-dimensional (multi-input and multi-output) efficiency measuring method using DEA and SFA. In the model, the small size farms mean an annually standard production value (STÉ) of 4 000 EUR - 25 000 EUR. There were data of 146 small and 201 large dairy farms in the sample. Among the 934 dairy farms in the sample, during the examined 13 years, using weights, the results can extend to a national level, and we can conclude that the technical efficiency of small farms varies between 67-69%. In contrast, the rate of the technical efficiency of large farms was between 70-77% during the 2001 - 2013 period. The partial efficiency indicators in respect of the 29 indicators have proved large farms' efficiency advantage in the event of most indicators against small and medium-sized farms. It can be concluded that the complex milk producing efficiency of small farms remained below the level of the efficiency of large-scale farms. The hypothesis set up on the basis of research results is considered to be justified.

H2. The technical- and major partial efficiency indicators of individual- and corporate farms are not significantly different.

The differences between the two legal forms can be identified as regards the technical efficiency of milk production. The efficiency of individual farms is 68%, while the efficiency of corporate enterprises is around 72-74% in the period on 2001 to 2013. The partial efficiency indicators confirm the higher technical efficiency of the corporate holdings case, their results are significantly different from the individual farms, thus this hypothesis is rejected.

H3. In terms of feed utilization efficiency, the large size dairy farms were more efficient than small farms.

The efficiency of feed quality can only be explored by defining target numbers and efficiency reserves. My results and models confirm that the feed cost amounted to 67% of the dairy farm total specific costs on the thirteen years' average. In case of the large farms, this efficiency reserve was 7% in this field, while in the case of small farms the efficiency reserve was 6%. The difference is not significant, because there are other cost items also included in this input factor, so this hypothesis does not considered as justified. The previous results somewhat contradicted the results of the next indicator, which is the

annual milk yield per 100 EUR feed cost. The reason why I chose this indicator is that the calculation of net income may differ from the large and small farms, which can bias the results. In the course of farm size comparison, the economies of scale advantages were dominating again, just like over the examined period the large farms on average can produce 999,3 kg milk with 100 EUR of feed cost. In contrast to this, the middle size farms during the thirteen years on average could produce 937,7 kg of milk with 100 EUR of feed cost; while the small scale farms can do the feeding on a lower efficiency level than other dairy farms. Small farms can produce 897,2 kg milk with 100 EUR of feeding cost on average. Based on the examined deterministic, stochastic and partial efficiency indicators, I cannot clearly determine whether farm size would influence the magnitude of technical efficiency regarding to the feeding cost, so I could not confirm my hypothesis. It is necessary to carry out a deeper investigation in this area to explore the reserves of the dairy feed technologies.

H4. The results of the most commonly used methods to analyse the technical efficiency (DEA and SFA) are approximately the same.

The results of Hungarian milk production technical efficiency (DEA and SFA) differ from each other, even though the main orientations shown the same for both methods. The two efficiency measuring methods examined the same issues (technical efficiency) with the same database but with different methodological tools. While one is a parametric (SFA) method, the other is a non-parametric (DEA) one. The efficiency score of the average weighted output orientated DEA VRS method was 68%, for the SFA method it was 68%. The last thirteen years average weighted efficiency score of the small farms was 67% in the case of DEA VRS configuration and 69% of the SFA configuration. The middle (60%; 68%) and large (70%; 77%) size farm case show much greater variations between the two methods, the difference can be between 7-8% between the two measuring methods. Based on this, I reject my hypothesis, because there are differences between the two measuring methods, but with professionally appropriate and justified parameters the results can fall very close to each other. In my opinion, the simplicity and easy parameter settings of the DEA method make it suitable to explore the area of efficiency

reserves and it could be much more useful for practitioners than the more complex, SFA method that requires serious mathematical programming knowledge as opposed to the DEA method, a simpler method based on linear programming. In my opinion, the SFA method is not suitable for measuring the Hungarian milk production efficiency.

H5. The main partial efficiency indicators show similar differences in different years, economics sizes and legal forms, as commonly used methods to analyse the technical efficiency (DEA and SFA).

The results of the DEA model for the analysed period showed that large farms in Hungary are mainly successful (77%). They were followed by small farms (67%), who are also able to use their size economic advantage well. The medium farms efficiency (60%) was much more left behind the other two-size categories during the examined period. The conclusion is that in the future the groups of dairy farms divided in two categories, the large size farms can operate on a high efficiency level with small size farms too, and there will be no transition between the two categories, thus there will be no middle size dairy farm left in the future. Based on the DEA model, the results the corporate farms were able to reach a higher efficiency level than individual farms during the examined period. Individual farms could enhance their performance by even 32-39% performance, while it is 16-18% for corporate farms. However, it should be noted that the sample included more individual farms than corporate ones. This also means that individual farms are less homogeneous than the corporation ones. The weighted results of the SFA models show that the efficiency of small farms (69%) of a percent lower than the effectiveness of the large farms (70%) in the period under research. The medium farms efficiency scores are the lowest (68%) among the other two size categories. Looking at the differences of individual and corporate farms, we can see that the efficiency of corporate farms (74%) is only 6% higher than that of individual farms (68%) and the efficiency values of their standard deviation is also lower in corporate farms cases.

The four areas examined (capital, labour, cost, herd) efficiency indicators show a very mixed picture in respect of each year, however,

I say that based on the results of large farms and corporate farms achieved class-highest result in the four main areas. Medium farms are in the second place among the examined indicators regarding the capital efficiency indicators. Based on the obtained results in milk production, small and individual farms present lower partial capital efficiency values than large corporate farms. Thus, the results of all the used efficiency methods demonstrate nearly identical results in the assessment of the efficiency of large holdings, because of their size in most cases can reach higher efficiently levels than small farms. Therefore, I proved my prior hypothesis, the DEA and the partial efficiency indicators are the most suitable methods to measure farm level efficiency. The more complex multi-dimensional deterministic DEA methods provides more benefits for the decision makers to identify the weak areas on the farm level. A problem with the DEA frontier is that it does not account for measurement errors and other sources of statistical noise. Thus, all deviations from the frontier are assumed to be the result of technical inefficiency (Coelli et. al. 2005). However, the DEA doesn't need functional specification, thus there is less room for misspecification, which makes more suitable to measure technical efficiency in the dairy sector. But the SFA models are usually more complicated than the DEA models, so there are main disadvantages of the SFA regarding the model specification (COELLI et al., 2005). The results of the Hungarian dairy farms efficiency differences come from these facts; hence, both methods can be useful to have a deeper snapshot of the dairy sector actual situation. In my opinion, the efficiency of Hungarian milk production can best be described by the most simple method (DEA), the results are supported by the partial efficiency indicators too.

The main proposals for development directions in the light of the efficiencies can include lower technical efficiency of small farms in the future, not to be allowed to compete with large-scale dairy farms in production; rather producing more specific milk contents to serve the needs of small size milk processing companies like higher fat and protein milk. In contrast with the primary purpose of large farms, their technical efficiency has to be increased to serve large industrial milk processing companies in the future and produce high amount of milk with low cost.

4 NEW AND NOVEL SCIENTIFIC FINDINGS

- 1) Based on the secondary database (FADN), I **created a partial efficiency index system** of economic efficiency in four main economic areas (*capital, production costs, human resources, livestock*) which were characterized by using dairy farms efficiency differences of different size, year and legal form categories.
- 2) I have **created** a Hungarian dairy farms adapted **stochastic (SFA) and deterministic (DEA) model**, in which the output variables were the **milk and milk products** and **meat** (as another income), featuring sold beef and veal. According to the model, five input factors were used: **(1) fixed assets, (2) current assets; (3) labour input, (4) major direct costs, (5) herd size**. The model input variables comes from Hungarian FADN database.
- 3) I proved that the **post-weighting adjustment is justified** by the DEA and the SFA methods, despite the fact that the method involves the incorporation of some uncertainties weighing inside the models. The results for individual farms confirmed that using additional weighting outside the model helps to make wider national-level statements about the milk production efficiency.
- 4) I confirmed that the used efficiency methods (DEA, SFA and partial indicators) for measuring **complex efficiency level were higher** in my sample in the case of the **large-sized farms** than the for small and medium-sized farms.

5 THE PRACTICAL USE OF THE RESULTS

The main results of the thesis are developing a stochastic, a deterministic and a partial efficiency model which are suitable not only to assess the efficiency of dairy farms, but are easily adaptable in other Hungarian agriculture sectors, so in the *field of agricultural economics research* can be effectively used.

An aspect of practical use can state that the developed efficiency models are useful for both *field experts* and *policymakers, decision makers* and follow-up monitoring.

Also, the methods developed can provide a good basis for *higher education students* in agri-business specialisation to learn in-depth efficiency analysis. The thesis topic also fits well to the Agri-business Science School of Debrecen traditions and can easily integrate to their *agri-business management* education materials.

Farmers working in milk production and efficiency controllers can use the results of partial indicators as a benchmark of their economies analysis. Such indicators may include fix asset value per 100 kg of milk yield; labour hours to produce 100 kilograms of milk; net income per 100 EUR direct cost; the annual milk yield per 100 EUR feed cost and the production value per dairy cow indicator.

One of the novel results of this thesis is the use of internationally applied DEA and SFA methods for the domestic dairy producers, and further research is necessary to examine the economic impact of the abolition of the milk quota system. The multidimensional efficiency models could help *individual producers, producer groups* to assess their national competitiveness in terms of the assessment of their own performance.



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Neptun ID: NGCDMC
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List of publications related to the dissertation

Article(s), studies (14)

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